ERI SUMMIT

ELECTRONICS RESURGENCE INITIATIVE

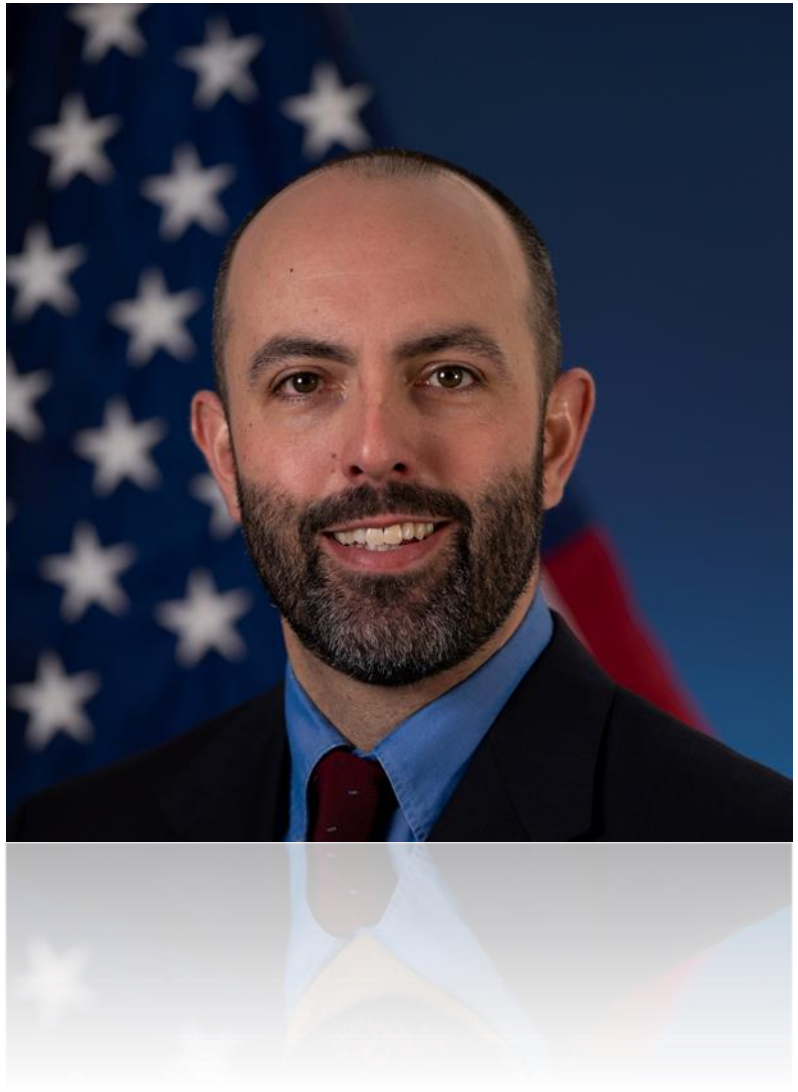
& MTO Symposium

MTO MICROSYSTEMS TECHNOLOGY OFFICE

DARPA

ERI ELECTRONICS RESURGENCE INITIATIVE
SUMMIT
& MTO Symposium

MEMS NEXT
(WORKSHOP)



BENJAMIN GRIFFIN

PROGRAM MANAGER
DARPA MTO

MICROELECTROMECHANICAL SYSTEMS (MEMS)

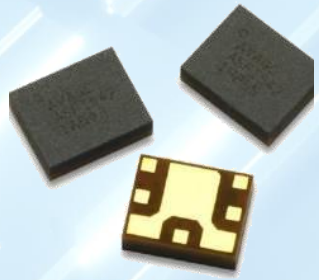
COMMERCIAL EXAMPLES:

Printhead

© Epson

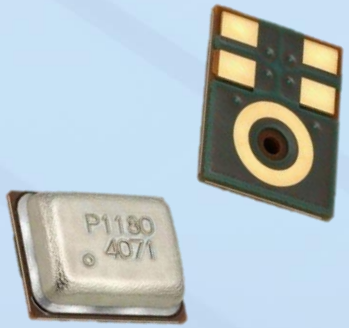
Gyroscope

© tdk.com



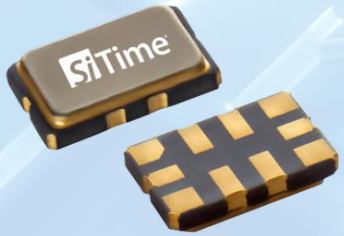
RF Acoustic Filters

© broadcom.com



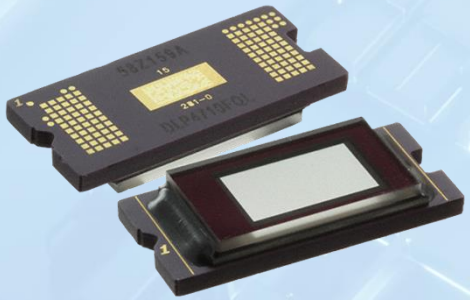
Microphone

© Knowles.com



Silicon clock

© SiTime'

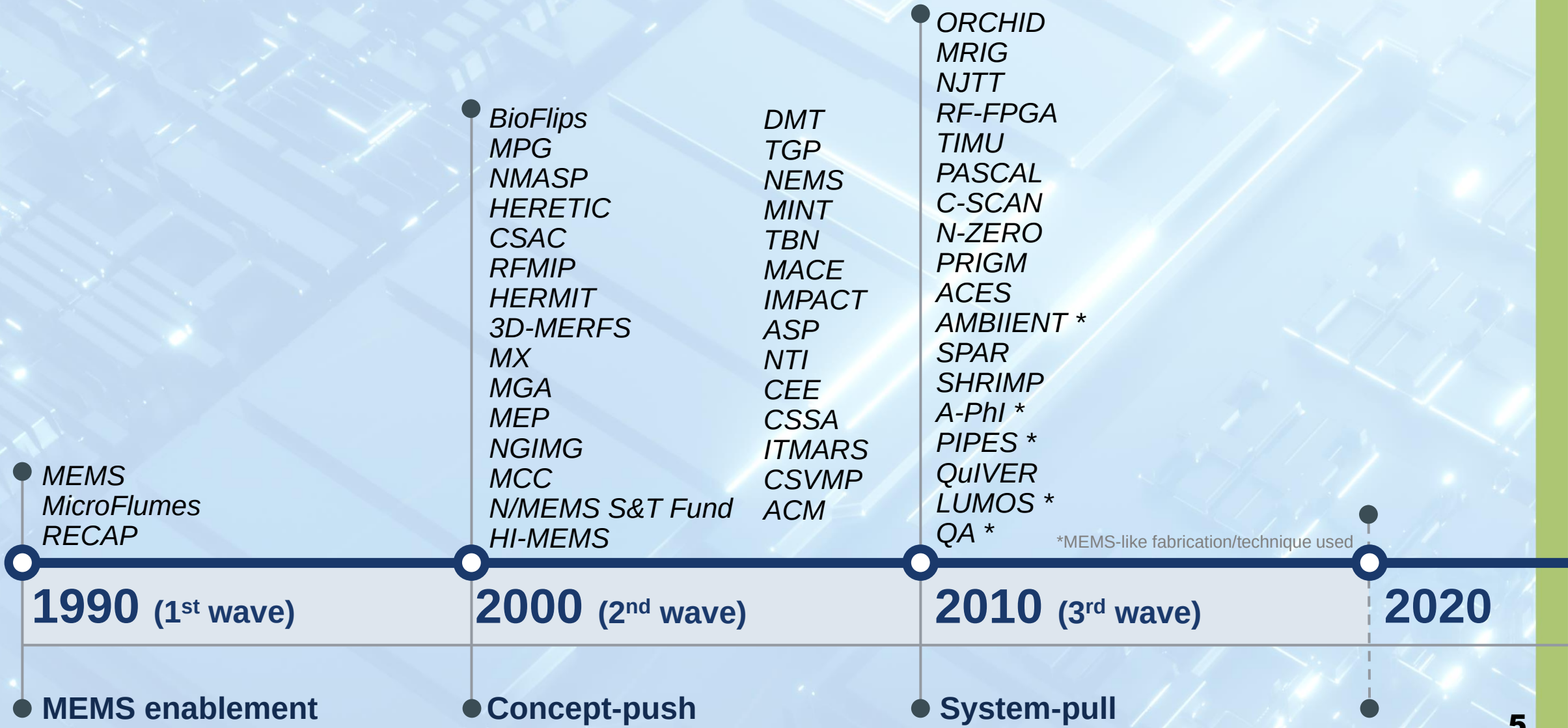


Micromirror

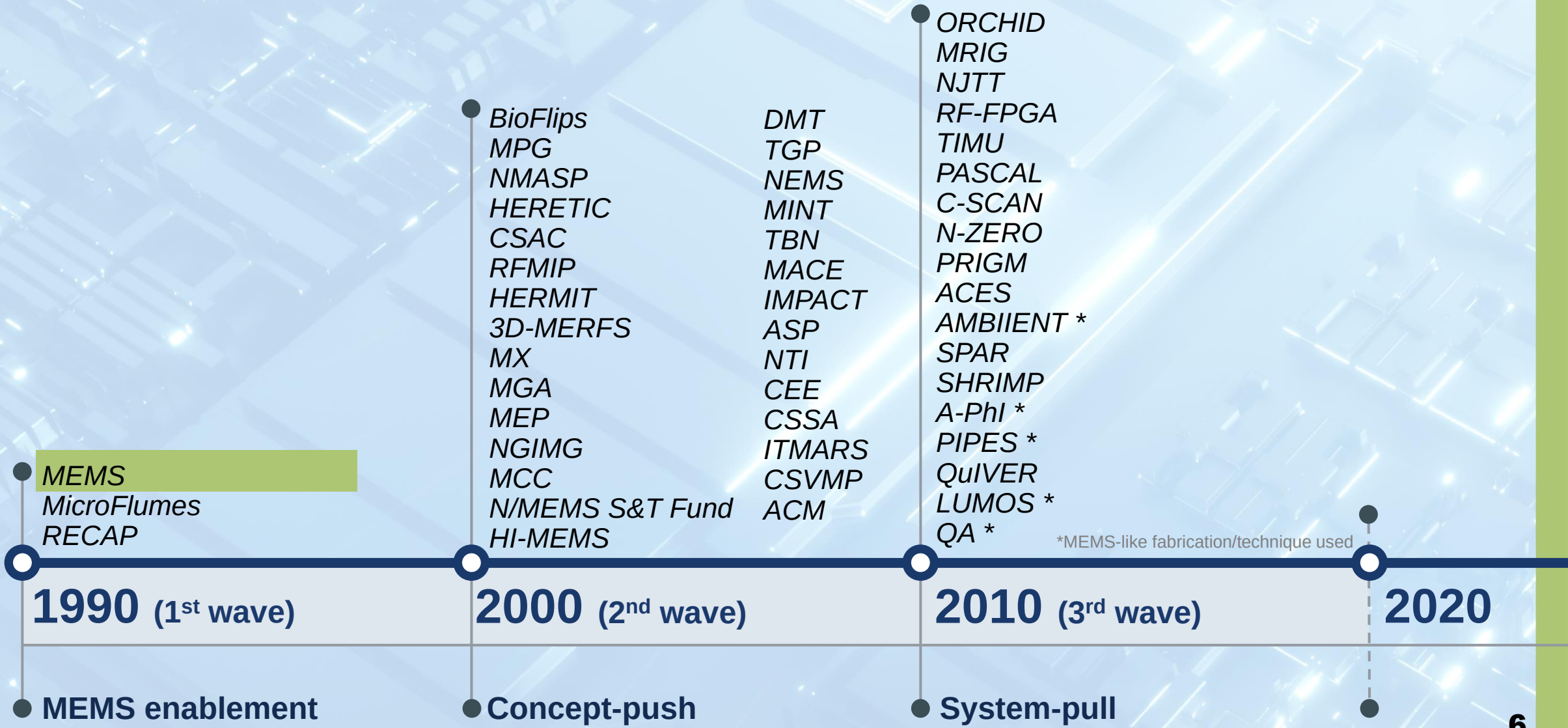
© Texas Instruments

MEMS: miniaturized devices and structures made using microfabrication techniques

DARPA MEMS HISTORY



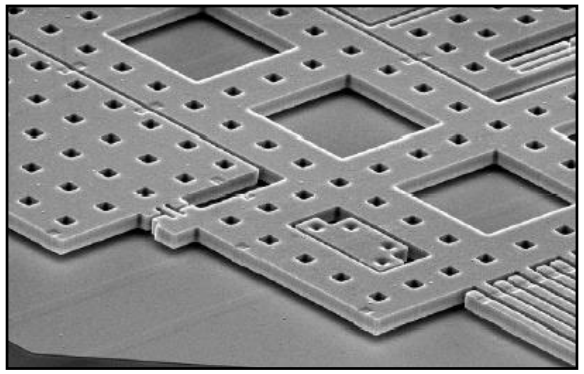
DARPA MEMS HISTORY



MEMS PROGRAM

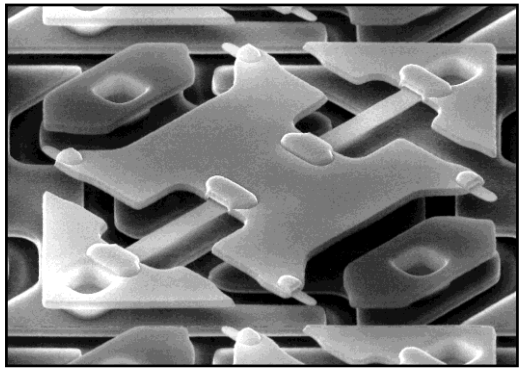
Dr. Ken J. Gabriel 1992-97
Dr. Al P. Pisano 1997-99

MICROELECTROMECHANICAL SYSTEMS



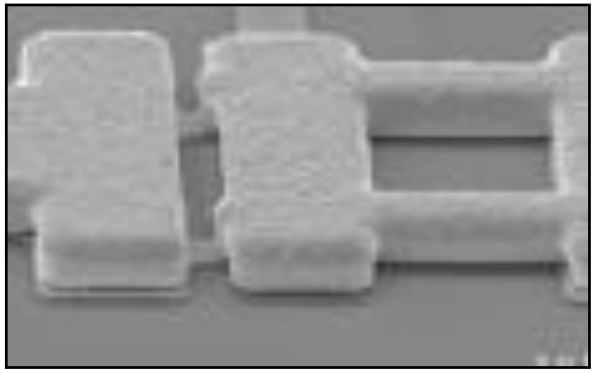
Analog Devices

Accelerometers



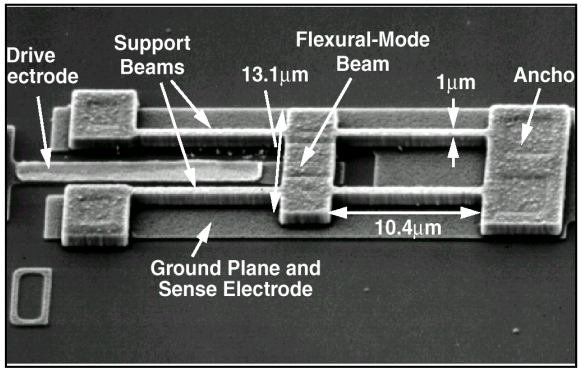
Texas Instruments

Displays



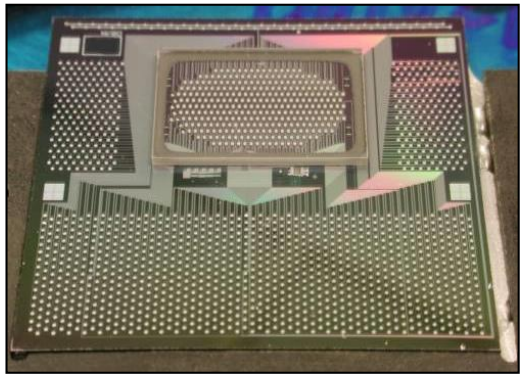
Radant MEMS

RF Switches



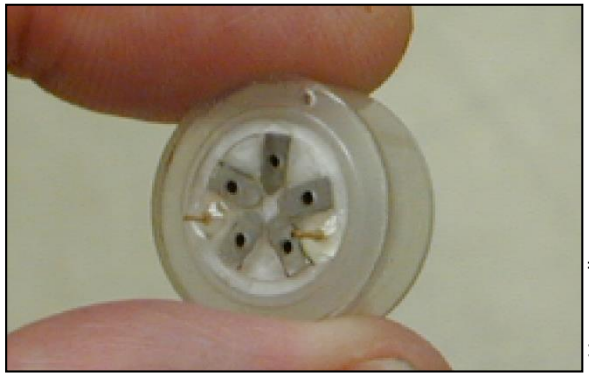
Nguyen, Michigan

RF Resonators



Calient Networks

Optical switches



Honeywell

Fuel Cells

Goal:

Merge computation, sensors, actuators, and mechanical structures to radically change the way people and machines interact with the physical world

Need:

MEMS fabrication, processes, and infrastructure

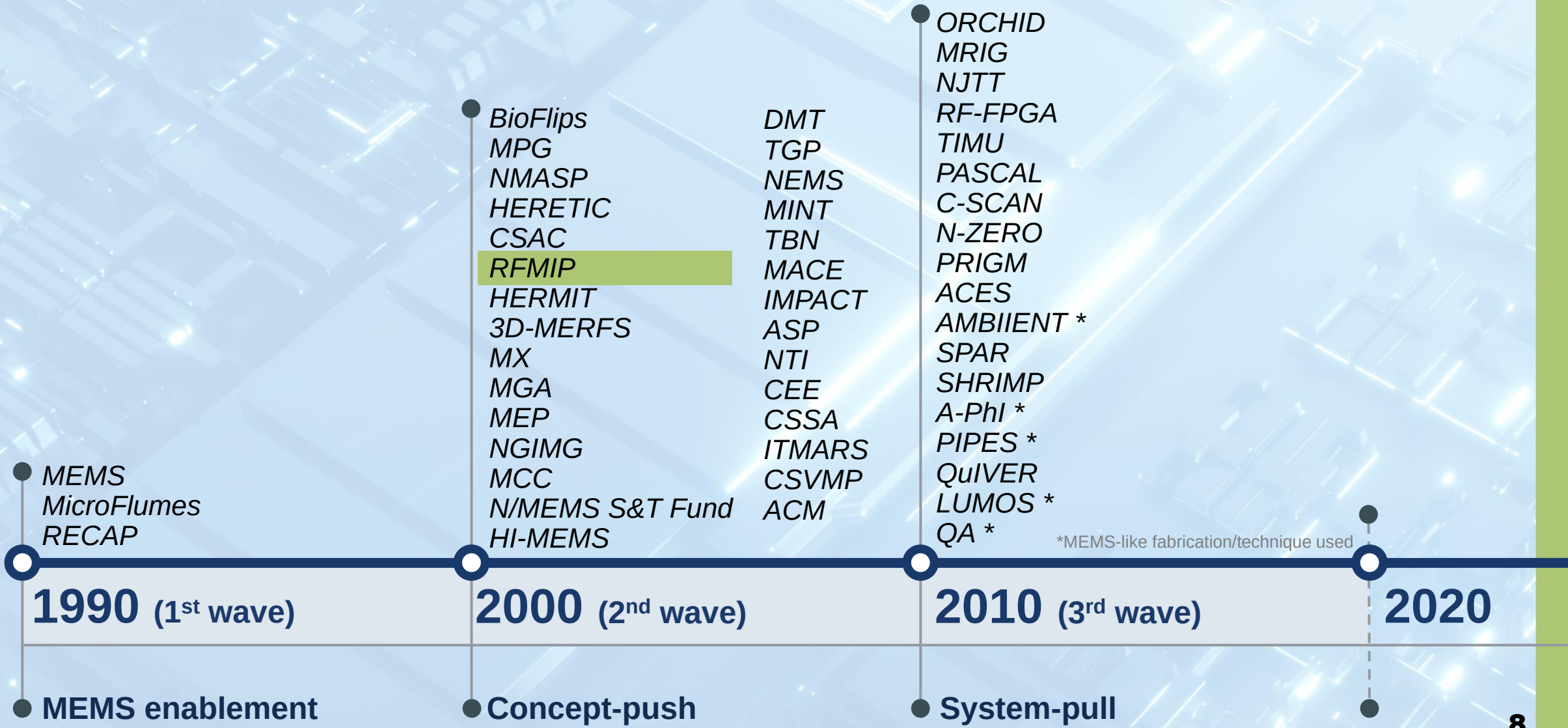
Key Accomplishments:

Successful component demonstrations

Offered shared access to a common MEMS fabrication process

MEMS enablement through development of micromachining building blocks

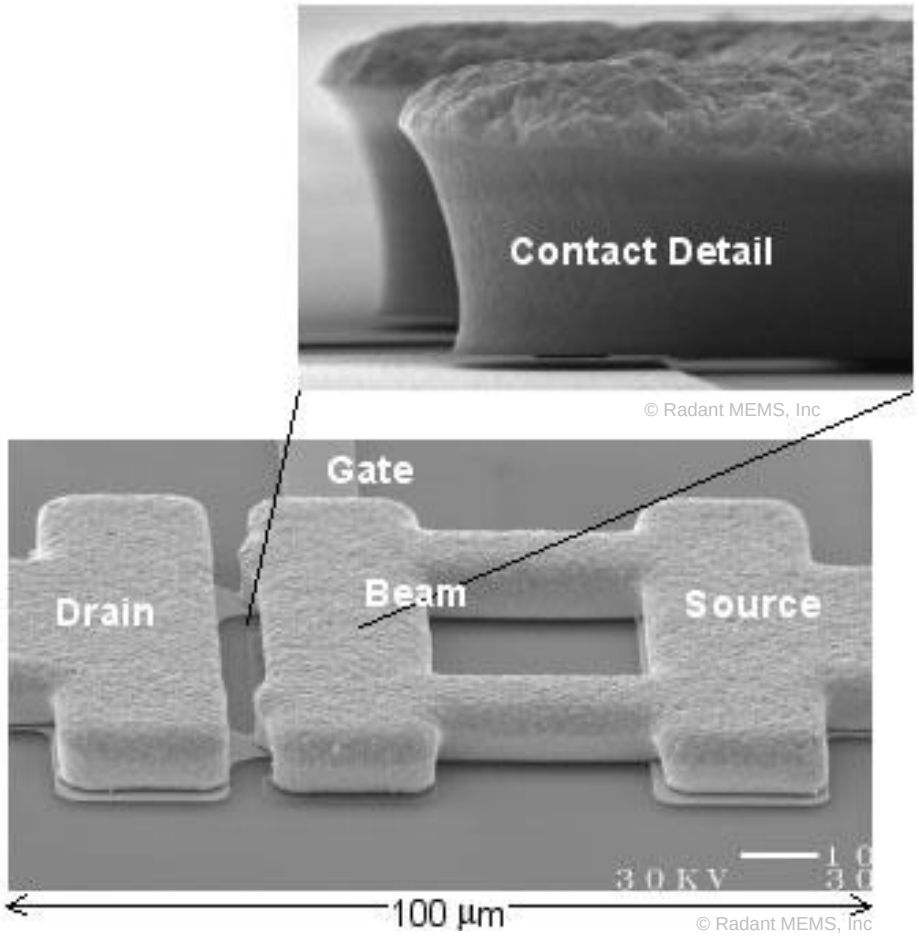
DARPA MEMS HISTORY

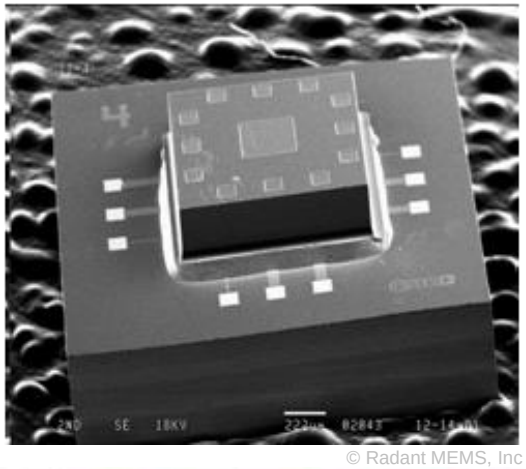


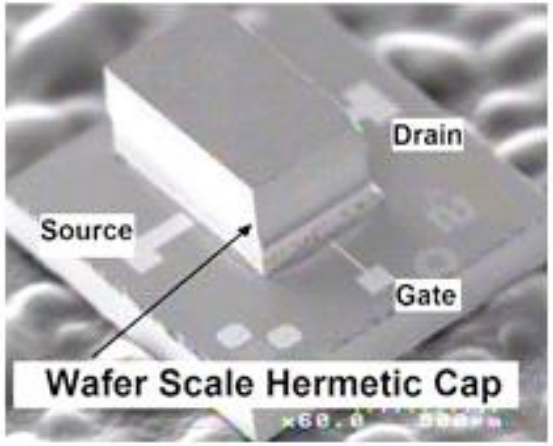
RFMIP PROGRAM

Dr. Clark T.-C. Nguyen 2002-05
Dr. John Evans 2005-06

RF MEMS IMPROVEMENT







Goal:

Robustness and reliability of MEMS technology for ultra-low loss signal switching

Need:

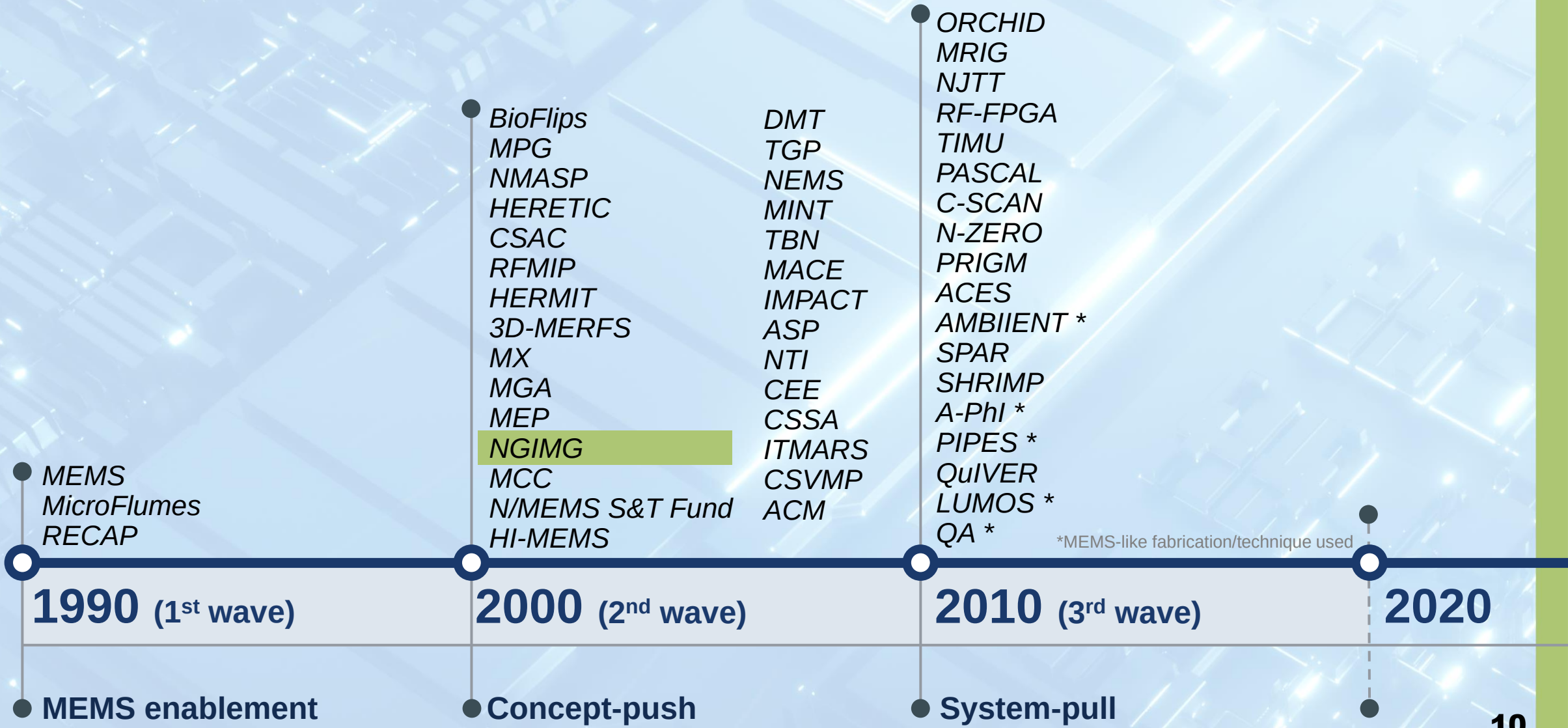
RF communication and electronic intelligence

Key Accomplishments:

RF MEMS switches with a long life cycle (500 billion cycles demonstrated)

Develop reliability of MEMS-specific approach for high performance switching

DARPA MEMS HISTORY

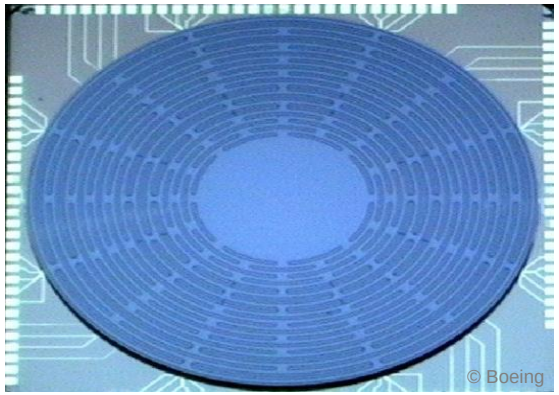


NGIMG PROGRAM

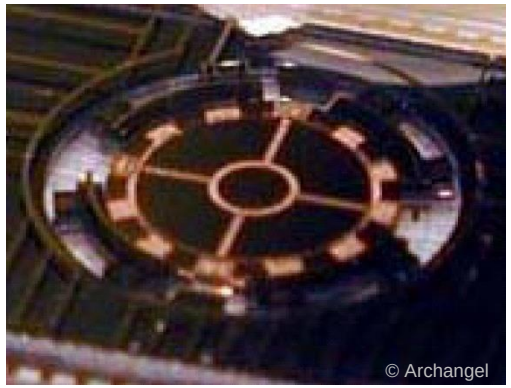
Dr. Clark T.-C. Nguyen 2005-06
Dr. Amit Lal 2006-09
Dr. Andrei Shkel 2009-13



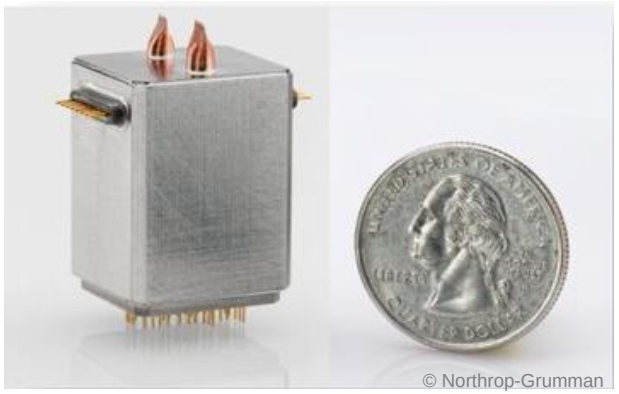
NAVIGATION-GRADE INTEGRATED MICRO GYROSCOPES



Disk Resonator Gyroscope



Spinning Mass Gyroscope



Nuclear Magnetic Resonance Gyroscope

SWaP: size, weight, and power
IMU: inertial measurement unit
UAV: unmanned aerial vehicle

Goal:

Navigation-grade performance from low SWaP MEMS gyroscopes and accelerometers

Achieve ultrahigh quality factor resonators, miniature nuclear magnetic resonance, and spinning masses

Need:

Wearable, low power IMU modules for dismounted soldier

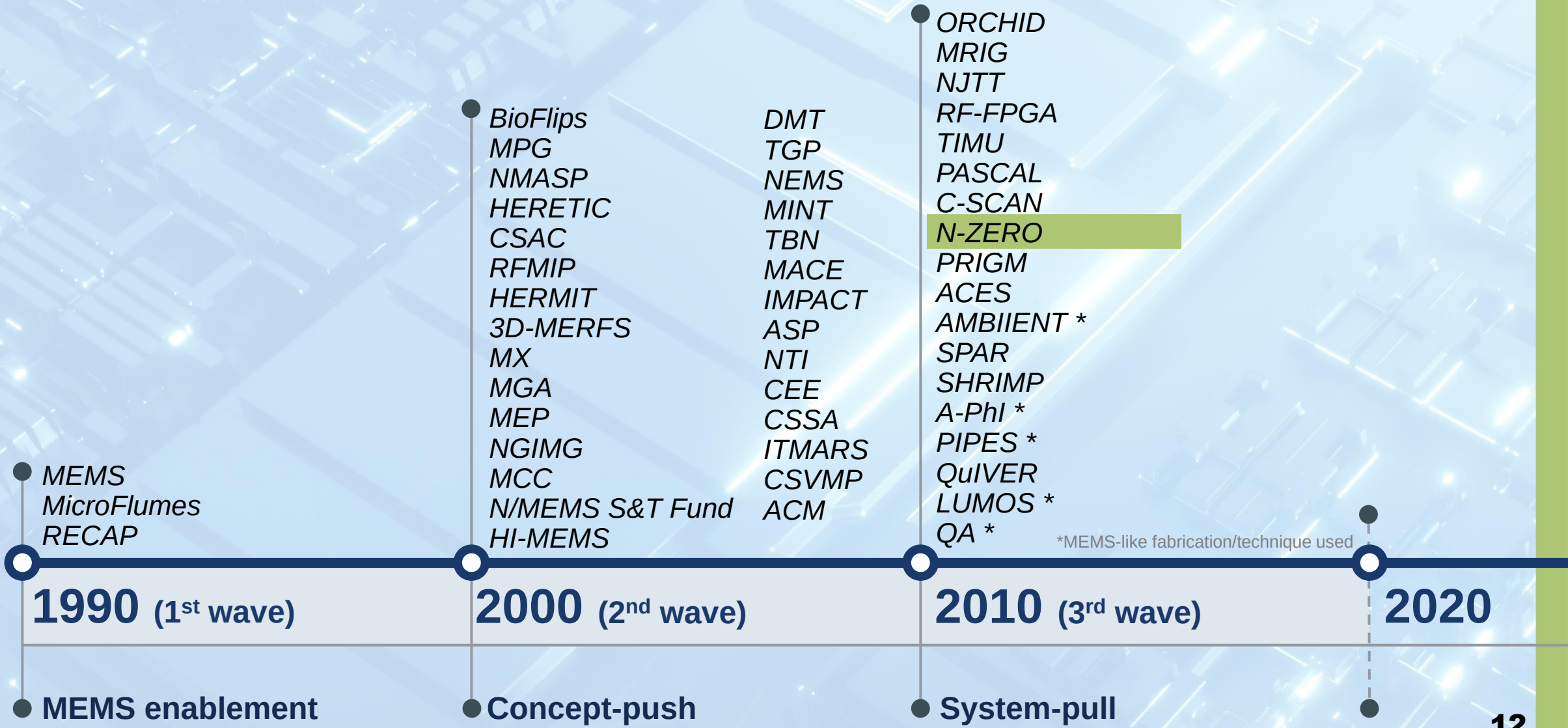
Guidance for munitions, UAVs, and insect-like robotics platforms

Key Accomplishments:

Nav-grade performance in nuclear magnetic resonance gyroscope on an optical bench

MEMS-specific miniaturized IMUs for navigation of SWaP constrained platforms

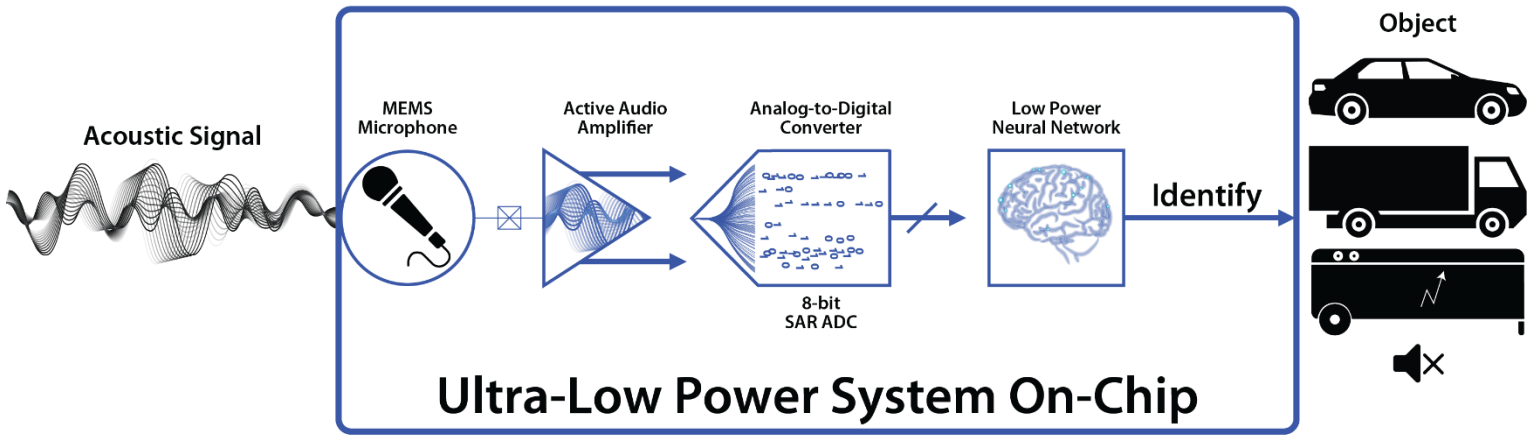
DARPA MEMS HISTORY



N-ZERO PROGRAM

Dr. Troy H. Olsson 2015-18
Dr. Benjamin Griffin 2018-20

NEAR ZERO POWER RF AND SENSOR OPERATIONS



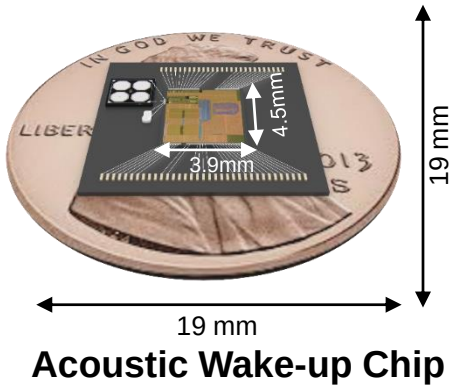
Goal:

Perform signature identification by sensing and process signals within a 10 nanowatt-level power budget

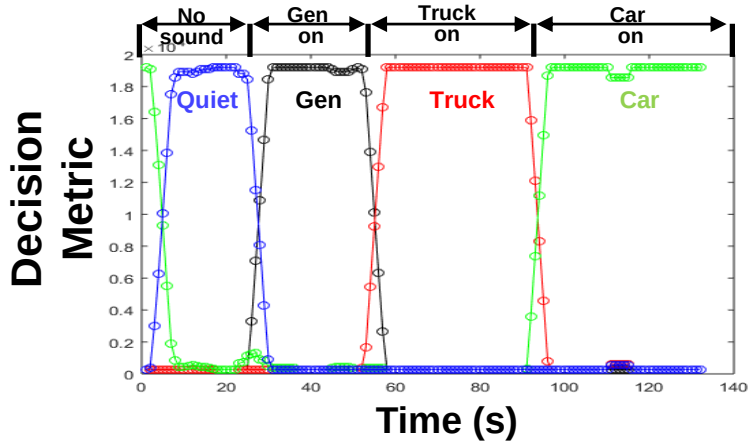
Need:

Provide the warfighter with event-driven sensing capability that drastically increase mission life

CR 2032 battery



Acoustic Wake-up Chip



Courtesy of University of Michigan

Key Accomplishments:

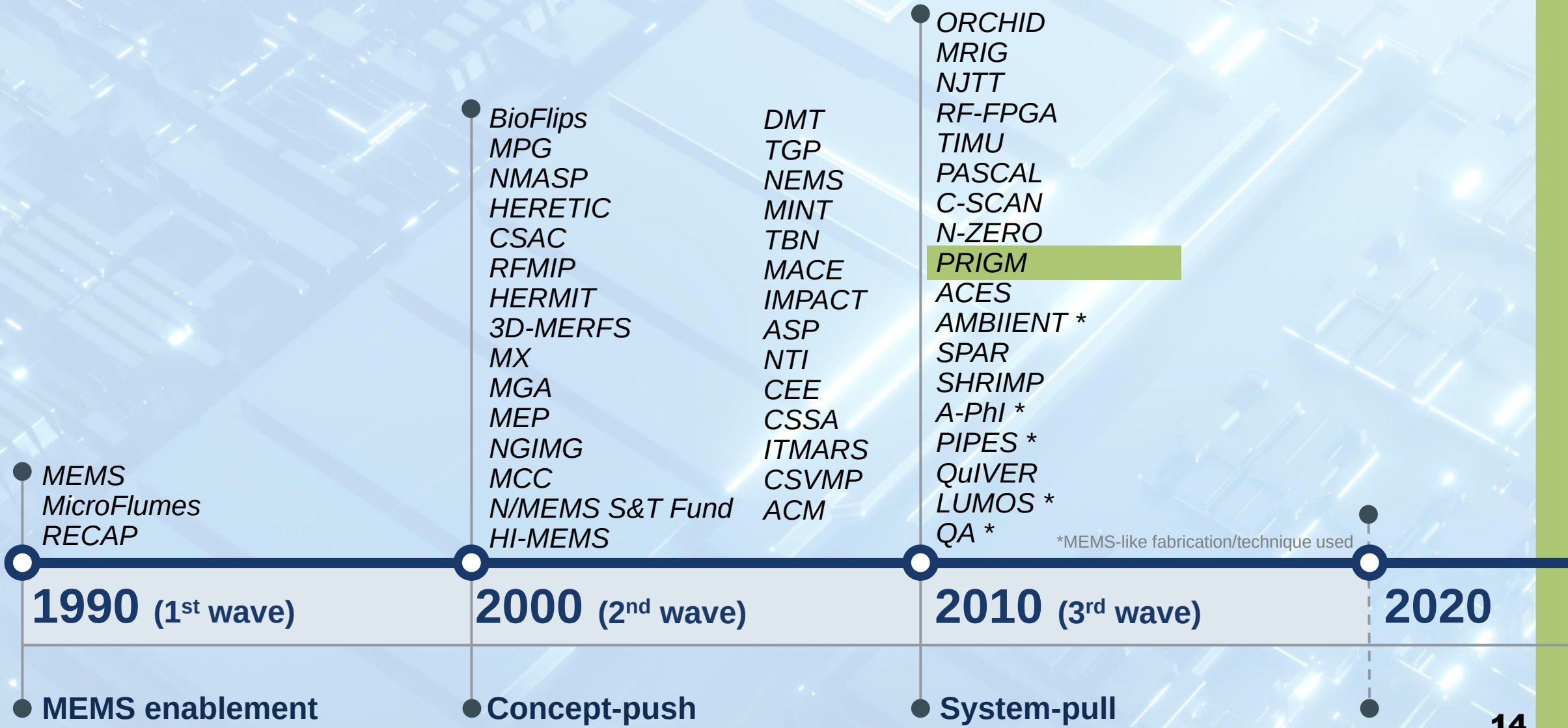
Acoustic wakeup using sub-threshold ASIC combined with MEMS microphone at just 20 nW

RF wakeup at -106 dBm and 433 MHz while consuming just 33 nW

Demonstrated processor with 10 nW sleep power

MEMS-enabled sensors that are **ASLEEP** yet continuously **ALERT**

DARPA MEMS HISTORY



PRIGM PROGRAM

Dr. Robert Lutwak	2015-2017
Dr. Ronald Polcawich	2017-2021
Dr. Benjamin Griffin	2021-202X

PRECISE ROBUST INERTIAL GUIDANCE FOR MUNITIONS

	State-of-the-Art		PRIGM
	 © Honeywell- Datasheet	 © Honeywell- Datasheet	 © Honeywell *JNC2021-Dual-Use Navigation-Grade MEMS IMU*
Model	HG9900	HG1930	PRIGM IMU
Volume (in^3)	100	5	5
IMU Grade	Navigation	Tactical	Navigation
Gyroscopes	Ring Laser	MEMS	MEMS
Accelerometers	Quartz	MEMS	MEMS

Goal:

Gun-hardened, navigation-grade performance within SWaP constraints of SoA MEMS-IMU

Need:

IMU-based navigation (180 s) of guided munitions in GPS-contested theaters

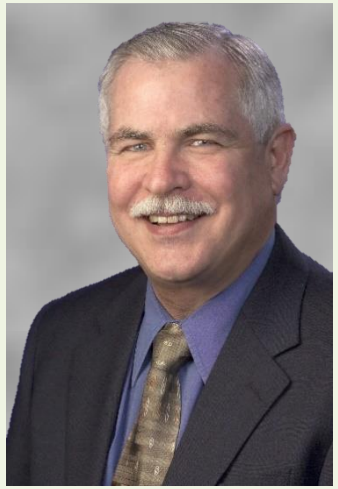
Key Accomplishment:

Multiple prototype IMUs for rapid transition through service lab capability demonstrations (expected)

SWaP: size, weight, and power
SoA: state-of-the-art
IMU: inertial measurement unit

MEMS enabled, gun-hardened IMUs for munition navigation in GPS-contested theaters

4TH WAVE OF MEMS: NEXT CHALLENGES



The Impact of Key New Technologies and Capabilities on the Future of MEMS

Kurt E. Petersen
Silicon Valley Band of Angels
Co-Chair of HardTech Group

Integrated Piezoelectric Microsystems: Novel Application Opportunities

Matt Eichenfield
Sandia National Laboratories
Distinguished Member

Health Monitoring: Examples, Challenges, and Opportunities for MEMS

Mark G. Allen
University of Pennsylvania
Alfred Fitler Moore Professor

2020

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